Changing the paradigm: messages for hand hygiene education and audit from cluster analysis

Running title: Messages for hand hygiene education and audit from cluster analysis

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Summary

Background: Hand hygiene is considered the foremost infection prevention measure. How health workers accept and make sense of the hand hygiene message is likely to contribute to success and sustainability of initiatives to improve performance, which is still often poor.

Methods: Survey of nurses in critical care units in three National Health Service trusts in England to explore opinions about hand hygiene, use of alcohol handrubs, audit with performance feedback and other key hand hygiene-related issues. Data were analysed descriptively and subjected to cluster analysis.

Results: Three main clusters of opinion were visualised, each forming a statistically significant group: positive attitudes, pragmatism and scepticism. A smaller cluster suggested possible guilt about ability to perform hand hygiene.

Conclusion: Cluster analysis identified previously unsuspected constellations of beliefs about hand hygiene that offer a plausible explanation of behaviour. Health workers might respond to education and audit differently according to these beliefs. Those holding predominantly positive opinions might comply with hand hygiene policy and perform well as infection prevention link nurses and champions. Those holding pragmatic attitudes are likely to respond favourably to the need for professional behaviour and need to protect themselves from infection. Greater persuasion may be needed to encourage those who are sceptical about the importance of hand hygiene to comply with guidelines. Interventions to increase compliance should be sufficiently broad in scope to tackle different beliefs. Alternatively cluster analysis of hand hygiene beliefs could be used to identify the most effective educational and monitoring strategies for a particular clinical setting.

Words in summary 250

Introduction

Hand hygiene is considered the foremost infection prevention measure (1) and is audited in many countries as part of quality assurance based on World Health Organization (WHO) recommendations (2) and national guidelines. Initially campaigns to improve hand hygiene are successful but compliance inevitably declines over time and is higher when auditors are present (3). WHO recommendations for hand hygiene are based on five components: ensuring that the correct resources are provided, education, observation of hand hygiene with performance feedback, workplace reminders and managerial support. All professional groups are targeted. The WHO and other guidelines strongly support use of alcohol handrubs on the premise that they are more convenient and cosmetically acceptable than traditional hand washing and have superior bactericidal effect against vegetative organisms. Interventions to increase compliance in some recent studies are based on WHO recommendations (4, 5) or include some but not all recommendations (6). Continuing poor compliance and failure to reduce rates of healthcare-associated infection is therefore disappointing and merits further investigation. Numerous studies have explored health workers' opinions of what could be done to improve compliance but none has looked at preferred approaches to education and monitoring (7, 8, 9). How health workers accept and make sense of these important components of the hand hygiene message is important because it is likely to contribute to the success and sustainability of initiatives to improve performance.

Methods

The aim of the study was to create a taxonomy of questions related to health workers' beliefs about hand hygiene based on theoretical constructs from the literature. Questions explored: whether health workers agreed that cleansing hands is the most important way to prevent infection, acceptability and efficacy of alcohol handrubs, value of hand hygiene audit, performance feedback and helpfulness of the Five Moments for Hand Hygiene (10). We developed a new questionnaire based on topics that had previously been regarded as important (2) but adding items that are emphasised in more recent international policy and research as the WHO guidelines were published over ten years ago and there have been considerable developments in hand hygiene and infection prevention since (11, 12).Although not recommended by the WHO, some managers employ disciplinary measures to improve compliance (13, 14). Healthcare in many countries is now highly litigious. Employers are required to take vicarious responsibility for the actions of health workers and respond to poor clinical performance through punitive interventions. Questions about its acceptability were therefore also included. Respondents were asked if they thought that all health professionals, patients and visitors should take responsibility for hand hygiene and if they were more likely to

cleanse hands if placed at personnel risk of infection or contamination because perceived need for self-protection promotes hand hygiene (15). They were asked if they believed that some health workers cleanse hands better than others as health workers appear to demonstrate favourable bias towards their own infection prevention practice while blaming others for poor performance (16). Initially a large pool of potential items was developed from policy and the literature. Questions finally included were decided by an expert panel which also scrutinised the questions to ensure clarity. The panel consisted of five experts who saw the potential questions in advance and met once to agree them. Panel members were chosen because of their expert knowledge of hand hygiene. A pilot study was conducted in one critical care unit (CCU) to assess face validity. No changes were necessary. Pilot data were not included in analysis. Mean time required to complete the questionnaire was four minutes.

Data were collected by survey questionnaire from nurses in CCUs in three National Health Service (NHS) trusts in England. All three NHS trusts provided a full range of acute services and has an emergency department. Each critical care units catered for 20-30 patients and employed general nurses and those with additional specialist qualifications in critical care. Data collection was restricted to a single professional group to remove the confounding effect of occupation because some professional groups are known to comply with hand hygiene more than others (17). The questionnaire comprised 36 fixed choice questions designed for rapid, straightforward completion (see Table I). Questions allowed respondents to give negative as well as positive opinions. Questionnaires were anonymous. Ethical permission was granted by the university research ethics committee where the principal investigator was employed. The study was discussed with the manager on each CCU to enlist support and encourage participation. The data collector visited regularly to encourage completion and collect questionnaires which were returned to a box placed on the nurses' station.

The data were analysed descriptively (means, medians, ranges) then subjected to cluster analysis. Originating in the biological sciences, this exploratory technique was initially used to classify organisms according to similarities that indicated underlying taxonomic relationships. It has since been employed in a range of disciplines including psychology (18) and marketing (19). People, products or occasions are classified according to similarity across a range of variables in an inductive approach that can identify structure within complex datasets, generate hypotheses, build theory, and predict relationships and behaviour (20). A two-step process was adopted in which

clusters were identified then interpreted and refined through discussion between members of the research team (20).

Analysis

Data were entered into R on the cluster package (https://cran.r-project.org/web/packages/cluster/cluster.pdf) and visualised on the heatmap.2 function within the gplots function to establish patterns indicating relationships between responses (21). Patterns were validated using the hclust function to generate a dendrogram cut at a dissimilarity height to reveal clustering (22). Both procedures adopted complete linkage clustering method to identify clusters of responses according to patterns from the maximum distances between components. This is an agglomerative method beginning with individual components which are then merged with their nearest adjacent cluster until a single cluster remains. Resulting clusters were inspected with the simprof function within the clustig package to determine the number of significant clusters according to the null hypothesis of a no a-priori group structure (23). The cluster package determines statistically significant clusters at a predetermined level of alpha (0.05). It does not calculate exact *p* values. The data in each cluster were inspected by two members of the research team who agreed external isolation and internal cohesion with third party agreement in cases of discord.

Results

One hundred and twenty one nurses returned questionnaires (response rate 75%) (see Table I). Three main clusters were visualised (Figure I). Each formed a statistically significant group. Pattern of responses in cluster 1 (questions 1, 6, 13, 9, 19, 20) depicted a positive attitude to hand hygiene. Informants whose beliefs clustered in this way agreed that hand hygiene is very important, a responsibility shared with patients and visitors who like to see it being undertaken and think that their own performance is good. This group are the enthusiasts. Pattern of responses in cluster 2 (questions 26, 33, 30, 27, 23, 29, 22, 15, 28) reflect a pragmatic view. This constellation of responses suggests that hand hygiene is taken seriously. Those holding pragmatic beliefs are content for managers and infection prevention personnel to witness their hand hygiene practice but still think their performance could be improved. They would report colleagues for poor performance. For those holding mainly pragmatic opinions audit is stressful and serves as a driver to improve practice. These respondents think that risk to self improves performance. Pattern of responses in cluster 3 (questions 21, 18, 3, 25, 14, 10, 8, 12 and 7) indicate a sceptical attitude. These respondents think that ability of hand hygiene to reduce heath care-associated infection is over-emphasised and can disrupt care, occasionally placing patients at risk and admit that their hand hygiene

could be improved. Surprisingly in view of these negative beliefs, responses in this cluster favour alcohol handrubs. We suggest that this apparently contradictory response might be because handrubs are quick and convenient to use. Preference for classroom-based updates possibly reflects dislike of practice being witnessed. Two smaller but distinct clusters were visualised. Cluster 4 seems to represent the opinions of individuals who feel guilty (questions 5, 31, 32). They know they could improve practice and do not consider sore hands an excuse. Questions in Cluster 5 (34, 35, 36) explored opinions about the Five Moments. Questions 16 and 17 are loosely associated and their tenuous relationship is probably spurious.

Discussion

Use of a theory-driven questionnaire allowing respondents to give negative as well as positive opinions combined with cluster analysis offers a new approach to planning hand hygiene interventions and provides insights that could improve the validity of hand hygiene audit, thus enhancing implementation of existing guidelines.

At present theories from the behavioural sciences are regarded as the best way of explaining health workers' failure to adhere to infection prevention precautions and improve compliance (24). These theories are occasionally used to underpin hand hygiene campaigns but although reporting positive outcomes, authors do not convincingly explain how theory explains the behavioural change they have observed (17, 25, 26). Continuing preoccupation with behavioural theory is hard to explain as most infection prevention interventions are intended primarily to protect patients, yet most behavioural theories seek to change behaviour to benefit the individual enacting the change, not encourage adoption of change to benefit others and indeed, the main driver of health workers' hand hygiene is self-protection (17). Theoretical Domains Theory (27) appears to be the only behavioural theory that can promote patient safety through health workers' behavioural change. It has been used to explore managers' but not clinicians' ability to implement a hand hygiene intervention (28).

Planning interventions

Initial descriptive analysis of our study findings suggests that health workers have absorbed the hand hygiene message. For example, 98% agreed that hand hygiene is the most important infection prevention precaution, 88% thought that total compliance is always ideal and 78.5% considered Five Moments useful to improve practice. Cluster analysis, however, identified a large constellation of beliefs suggesting that for some health workers the predominant beliefs point towards scepticism concerning effectiveness, while a smaller constellation of responses suggest guilty feelings about

hand hygiene performance (see Figure 1). Presenting respondents with negatively as well as positively worded questions helped to overcome social desirability which is the tendency to answer questions in a manner considered favourably by others (29).

The findings suggest that while those holding predominantly enthusiastic beliefs accept the hand hygiene mantra while those whose responses fall mainly in the sceptical cluster may be aware that many infection prevention precautions are not supported by evidence that would be considered robust. 'Enthusiasts' are likely to accept information in policy documents readily, respond to innovations to improve practice with alacrity and are probably effective as infection prevention link staff and champions. These roles are considered vital in recent policy to prevent healthcare-associated infection and reduce risks of antimicrobial resistance (11, 12). Selecting good ambassadors is therefore central to success. There is evidence that nurses can be effective in these roles (30, 31, 32). Health workers holding predominantly sceptical beliefs are less likely to perform well as link personnel and champions and will probably require more persuasion to accept that hand hygiene is important. Those holding a pattern of beliefs indicating guilt might benefit from discussion about factors in the workplace that could be improved to optimise performance. Continuing criticism and reminders to perform better may undermine morale. The large number of informants holding pragmatic opinions is a promising finding. Although these informants dislike hand hygiene audit, they understand its importance and the value of hand hygiene more generally. This group is likely to respond well to interventions that appeal to their responsibility to behave in a professional manner, set a good example to others and the need to protect themselves from infection.

International guidelines (2) to promote hand hygiene compliance recommend a multimodal improvement strategy. Recommended campaigns are multimodal. Individual campaigns undertaken by some research teams have emphasised some of these recommended components more than others but within the same campaign the same components are targeted at all health workers (4, 5, 6). Our findings suggest that interventions might be more successful if they adopt a broad approach to meet the needs of all staff. Building on the findings of this study such an intervention would consist of three key components: an evangelistic message to meet the needs of those holding predominantly positive opinions, presenting the best and most recent evidence that hand hygiene can be effective to meet the needs of those holding predominantly sceptical opinions and securing health worker engagement to meet the needs of all staff, especially those who feel insecure in their hand hygiene practice.

In view of the large cluster of positive opinions regarding hand hygiene identified in this study, it appears that evangelistic messages contained in contemporary policy documents have been successful and should continue to be used. Health workers should therefore be reminded about the intrinsic value of hand hygiene, its theoretical ability to break the chain of infection, aesthetic desirability and the importance of meeting patient and public expectation that it is being undertaken. Evangelism is unlikely to change sceptical patterns of beliefs, however. To reach this group interventions should include evidence that hand hygiene can be effective. A systematic review of very early studies to promote hand hygiene compliance (33) concluded that study designs were insufficiently robust to provide firm conclusions about its effectiveness. A second review of studies published up to 2009 concluded that evidence of effectiveness was weak (34). More recent studies are better controlled and there is now evidence, although still not of the highest quality, that hand hygiene can reduce healthcare-associated infection (4, 5, 6, 26). Health workers could also be encouraged to reflect on the level of evidence necessary before the decision to adopt a health care intervention should be taken, especially one that is relatively straightforward and inexpensive compared to many others that have been implemented. A two-pronged approach could be adopted in the engagement component. This aspect of the intervention could include discussion between clinicians, managers and infection prevention personnel concerning local barriers and enablers to hand hygiene. These have been identified in previous research (35) and need addressing locally to reassure all staff, but especially those under-confident and anxious about performance, that managers are sympathetic to infection prevention challenges and prepared to find ways to enable health workers to practise successfully. Secondly, health workers' opinions should be considered when hand hygiene initiatives are planned and implemented. Existing strategies to improve compliance rely heavily on education which in all other disciplines is evaluated to plan the next learning cycle. Its absence in nearly all initiatives to increase hand hygiene and other infection prevention strategies contradicts sound educational practice. Interventions in health care increasingly consider service user perspectives and in some countries, notably the United Kingdom, research funding is only granted when they contribute to research design, data collection and analysis. The service user in infection prevention improvement initiatives is arguably the clinician, yet their views are seldom considered when planning and implementing new initiatives, thus ignoring that health workers' acceptance and ability to make sense of infection prevention interventions are likely to contribute to success and sustainability.

Audit

The different views held by health workers concerning hand hygiene audit and performance feedback might have potential to increase the validity of audit findings. As it is impossible to observe all staff in a clinical area (36) the WHO (2) recommends selecting health workers randomly to avoid bias. Randomisation is seldom reported in research studies and is not feasible during routine audit, however (3). The Hawthorne effect (37) in hand hygiene has been widely discussed but the impact that presence of auditors has on patterns of work in the clinical environment or type of work that staff undertake during the audit period has received far less attention (3). The arrival of auditors might prompt health workers to delay complex procedures (e.g. complicated dressings, catheterisation) that require frequent, multiple hand hygiene episodes or deliberately move to non-clinical tasks. This behaviour is undetected and can bias findings because audit periods are typically brief, often as little as 20 minutes (3). Managers aware that health workers might hold sceptical or guilty beliefs will be better placed to identify avoidant behaviour and adopt strategies to ensure they include all staff in audits. Deliberate or unconscious selection of 'enthusiasts' could distort audit findings if their levels of compliance are higher than the norm. 'Pragmatists' appear to be the group most likely to respond to audit by improving compliance, at least temporarily. Finally for audit findings to be meaningful, it is important to include a full range of clinical procedures, not just those that are readily observable. There needs to be debate about the value of short, frequent hand hygiene monitoring versus longer audit periods that involve high risk procedures when breaches in hand hygiene protocol have the most serious consequences. Longer, more detailed monitoring will be more resource-intensive and might need to be undertaken less often but might be more meaningful.

Study limitations

The study should be undertaken with a more diverse sample to establish whether the same patterns emerge and hold true across different professional groups. The CCU is a very specific hospital setting and the findings may not be generalisable to nurses employed in other services and settings. Responses to questions about Five Moments failed to cluster with those indicating other favourable opinions, a finding that is surprising and merits re-examination. Health workers have reported fatigue with imperatives to improve infection prevention (38). We avoided collecting sociodemographic data to keep the questionnaire short and encourage completion but variables such as gender and age could influence hand hygiene beliefs and should be included in future studies. The major weakness of the study is that espoused beliefs do not guarantee the behaviour predicted. Future research could explore whether this relationship holds good. If the clusters we identified are replicated in other studies and predict behaviour, the questionnaire could be used to 'diagnose' wards according to the

predominantly held hand hygiene beliefs and hand hygiene interventions could be customised to meet local need, re-assessing and changing the approach over time as required.

Conclusion

Cluster analysis identified previously unsuspected constellations of beliefs about hand hygiene that offer a plausible explanation of behaviour. Health workers might respond to education and audit differently according to these beliefs. Those holding predominantly positive opinions are likely to comply with hand hygiene policy and perform well as infection prevention link nurses and champions. Greater persuasion may be needed to encourage those who are sceptical about the importance of hand hygiene to comply with guidelines. Interventions to increase compliance should be sufficiently broad in scope to tackle different beliefs. Alternatively cluster analysis of hand hygiene beliefs could be used to identify the most effective educational and monitoring strategies for a particular clinical setting.

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Table I. Responses to the questionnaire

	1	2	3	4	5	Total
Q1 Hand hygiene is the most important infection prevention procedure	90 (74.4)	29 (24)	1 (0.8)	1 (0.8)	0	121
Q2 Alcohol hand-rubs are more convenient than soap	23 (19)	66 (54.5)	1 (0.8)	8 (6.6)	23 (19)	121
Q3 I need to learn more about hand hygiene	1 (0.8)	27 (22.3)	10 (8.3)	30 (24.8)	53 (43.8)	121
Q4 More could be done to educate health workers about hand hygiene	10 (8.3)	64 (52.9)	8 (6.6)	8 (6.6)	31 (25.6)	121
Q5 There are times when I could improve my hand hygiene	14 (11.6)	83 (68.6)	2 (1.7)	6 (5)	16 (13.2)	121
Q6 Some health workers perform hand hygiene better than others	47 (39.2)	66 (55)	1 (0.8)	2 (1.7)	4 (3.3)	120
Q7 Alcohol hand rubs are always a better choice than soap	2 (1.7)	9 (7.5)	7 (5.8)	60 (50)	42 (35)	120
Q8 Hand hygiene is promoted at the expense of other infection prevention activities	6 (5)	30 (24.8)	13 (10.7)	13 (10.7)	59 (48.8)	121
Q9 My hand hygiene technique is good	26 (21.5)	87 (71.9)	1 (0.8)	0	7 (5.8)	121
Q10 There are times when you're just too busy for hand hygiene	7 (5.8)	38 (31.4)	5 (4.1)	27 (22.3)	44 (36.4)	121
Q11 It is right to discipline health workers for not performing hand hygiene	28 (23.1)	60 (49.6)	4 (3.3)	9 (7.4)	20 (16.5)	121
Q12 How often you clean your hands is more important than how thoroughly you do it	3 (2.5)	21 (17.4)	9 (7.4)	33 (27.3)	55 (45.5)	121
Q13 Patients and visitors must take some responsibility for hand hygiene	45 (37.2)	68 (56.2)	1 (0.8)	1 (0.8)	6 (5)	121
Q14 Occasionally stopping to clean hands would endanger the patient	11 (9.1)	37 (30.6)	5 (4.1)	30 (24.8)	38 (31.4)	121
Q15 I never miss an opportunity to perform hand hygiene	17 (14)	51 (42.1)	8 (6.6)	3 (2.5)	42 (34.7)	121
Q16 Having feedback helps me improve my hand hygiene performance	18 (14.9)	80 (66.1)	3 (2.5)	2 (1.7)	18 (14.9)	121
Q17 Hand hygiene can't prevent all infections	26 (21.5)	64 (52.9)	5 (4.1)	13 (10.7)	13 (10.7)	121
Q18 Alcohol hand rubs prevent hands from becoming sore	12 (9.9)	22 (18.2)	11 (9.1)	39 (32.2)	37 (30.6)	121
Q19 Patients and visitors like to see hand hygiene being performed	54 (44.6)	57 (47.1)	3 (2.5)	1 (0.8)	6 (5)	121
Q20 100% hand hygiene is always ideal	66 (54.5)	41 (33.9)	1 (0.8)	6 (5)	7 (5.8)	121
Q21 Too much reliance is placed on hand hygiene as an infection prevention measure	22 (18.2)	27 (22.3)	9 (7.4)	19 (15.7)	44 (36.4)	121
Q22 I would tell my manager if I thought a colleague wasn't cleaning their hands enough	9 (7.4)	53 (43.8)	9 (7.4)	18 (14.9)	32 (26.4)	121
Q23 I perform hand hygiene better if there is a risk to myself	20 (16.5)	55 (45.5)	6 (5)	7 (5.8)	33 (27.3)	121
Q24 I prefer to receive hand hygiene updates in my workplace	19 (15.7)	64 (52.9)	9 (7.4)	1 (0.8)	28 (23.1)	121

Q25 I prefer to receive hand hygiene updates in the classroom	4 (3.3)	22 (18.2)	19 (15.7)	14 (11.6)	62 (51.2)	121
Q26 Patients and visitors are not deceived, hand hygiene is still poor	1 (0.8)	41 (33.9)	22 (18.2)	9 (7.4)	48 (39.7)	121
Q27 I am happy for my hand hygiene to be audited by the infection control nurses	4 (3.3)	56 (46.3)	16 (13.2)	8 (6.6)	37 (30.6)	121
Q28 I am happy for my hand hygiene to be audited by peers	14 (11.6)	56 (46.3)	10 (8.3)	4 (3.3)	37 (30.6)	121
Q29 I am happy for my hand hygiene to be audited by managers	7 (5.8)	49 (40.5)	11 (9.1)	9 (7.4)	45 (37.2)	121
Q30 I perform hand hygiene better when I know somebody is watching	22 (18.3)	37 (30.8)	4 (3.3)	20 (16.7)	37 (30.8)	120
Q31 Having sore hands should not prevent hand hygiene	26 (21.5)	66 (54.5)	8 (6.6)	4 (3.3)	17 (14)	121
Q32 I feel guilty if I do not perform hand hygiene	26 (21.5)	69 (57)	7 (5.8)	4 (3.3)	15 (12.4)	121
Q33 Having my hand hygiene audited is stressful	14 (11.6)	51 (42.1)	7 (5.8)	11 (9.1)	38 (31.4)	121
Q34 I have heard of 'My 5 Moments for Hand Hygiene'	42 (34.7)	55 (45.5)	6 (5)	4 (3.3)	14 (11.6)	121
Q35 'My 5 Moments' is a useful tool in improving hand hygiene	35 (28.9)	60 (49.6)	11 (9.1)	1 (0.8)	14 (11.6)	121
Q36 I know exactly when to clean my hands because of 'My 5 Moments'	32 (26.4)	59 (48.8)	10 (8.3)	5 (4.1)	15 (12.4)	121

Key

1 = strongly agree

2 = agree

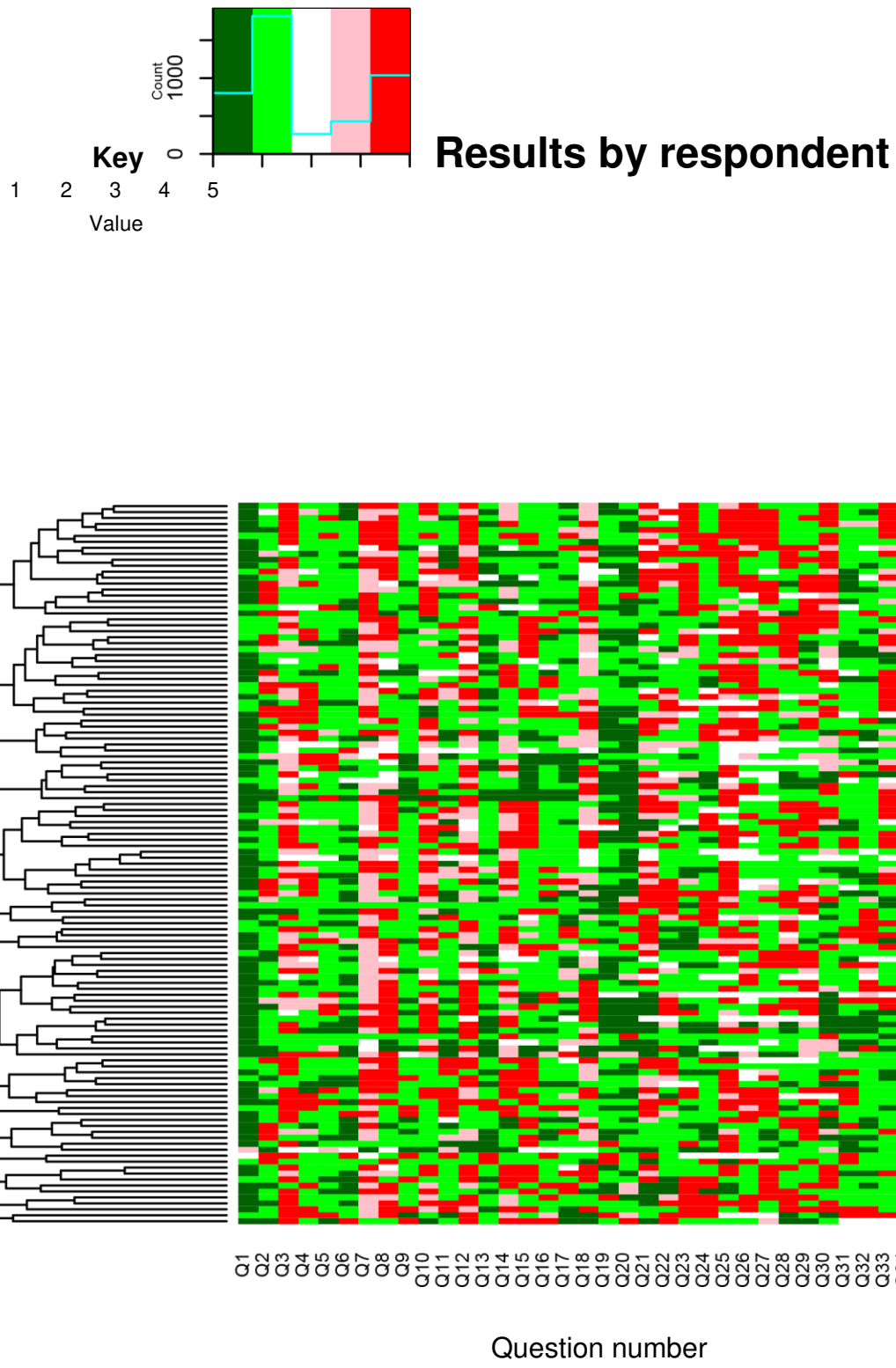
3= not sure

4= disagree

5= strongly disagree

Figure I. Results of cluster analysis

Figure I


Key
Count
1000
0
1 2 3 4 5
Value
Results by respondent
Respondent [site]
Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9 Q10 Q11 Q12 Q13 Q14 Q15 Q16 Q17 Q18 Q19 Q20 Q21 Q22 Q23 Q24 Q25 Q26 Q27 Q28 Q29 Q30 Q31 Q32 Q33 Q34 Q35 Q36
Question number

Author contributions

DJG and NSD conceived the study and led questionnaire development. DN collected data. EP and DN undertook analysis. DJG, EP and NSD interpreted the findings. SC provided advice about use of theory. All authors contributed to writing and reviewing the paper

Conflict of interest

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